Title: **Development of a Novel Radiatively/Conductively Stabilized Burner for Significant Reduction of NO_x Emissions and for Advancing the Modeling and Understanding of Pulverized Coal Combustion and Emissions**

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Abstract

1. Administrative aspects.

Since the grant has officially started on 30 September 1997, all the graduate admissions for academic year 1997/8 to our departments were closed by that time, and we were unable to immediately hire the graduate student for working on this project. In the meantime we have hired a Ph.D. student who already has an M.S. degree in the area of combustion and reduction of NO_x emissions. He will start with us just before the beginning of academic year 1998/9, at the latest on 1 September 1998. His past experience in the field of this project is expected to accelerate his effective research contributions. We also have good prospects for additional student help for the project, through non-DOE funded sources, such as federal work-study and senior projects.

Encouraged by the FETC project monitor, Dr. Philip Goldberg, we have made contacts with the two other groups engaged in DOE funded research on reducing NO_x emissions in coal combustion (Prof. Wendt, U. of Arizona with Prof. Sinclair, Purdue U., and Profs. Pershing, Lighty and Sarofim, U. of Utah) to explore ways of cooperation in this work. We have agreed among us on several specific cooperative efforts, as well as on continued communications for extending this cooperation as the projects develop.

We have visited several combustion research centers engaged in work pertinent to our project (including the University of Arizona, Åbo Akademi University, Finland, the University of Lund, Sweden, and Nagoya University, Japan) to make presentations of our research and to learn about their activities and techniques. The outcome of these visits would be very useful in our work on this project.

2. Primary research accomplishments.

We have primarily engaged in continuing our process modeling and analysis, and making preparations for the experimental work

In an attempt to study ways for reducing NO_x emissions from radiatively/conductively stabilized combustors (RCSC) for pulverized coal, our conjugate heat&mass transfer and reaction kinetics model of that combustor was improved. As compared with our previous simple three-reaction model, a global reaction model (Mitchell and Tarbel, 1982) is used in this new model to simulate volatile-NO formation and destruction along with the Zeldovich mechanism for thermal NO_x., and a ten-equation kinetic mechanism suggested by the authors and their co-workers (Arai et al. 1986) is used for the char-NO formation process. Thirteen chemical species are now included, and the mass conservation equations for the species, taking into account mass convection and diffusion was added to the previous model. The radiative properties of the different solid and gaseous components in the combustor are expressed by simplified expressions we have developed, which give acceptable errors, yet a much faster computation than the solution of the Mie equations.

We find with this new model that the radiation intensity distribution shows a substantial decrease in the flame region as compared to the intensity obtained form the previous model having simpler kinetics, because the new model shows production of less of the strongly emitting species CO_2 and H_2O in that zone. Because it is difficult to find values of multi-component gas diffusion coefficients suitable for the conditions of such burners, we have conducted a sensitivity analysis of the effects of deviations in the values of binary diffusion coefficients on the performance and emissions predictions of such burners. The effect of a 10% deviation in the diffusion coefficients on the results was found to be negligible, indicating that the use of binary coefficients instead of those for a multi-component system may be good enough in such combustion modeling.

We have also studied the effects of changing combustor wall conductivity, thickness and emittance, as well as flame location on NO_x emissions. Flame location was found to have little effect (~6%) and internal wall emittance an insignificant effect. While the concentration of these emissions was lowered by lowering the flame temperature, accomplished by increasing the excess air ratio, the overall mass of NO emitted with the thicker lower-temperature flames produced by such increases in excess air was much higher, indicating that the RCSC with its capability for producing a high temperature thin flame is much more effective for the reduction of NO emissions than some lower temperature combustion alternatives.

3. Publications and presentations about this project.

From the start of this project (30 September 1997) till 30 May 1998 we have presented and published one paper, had another paper accepted for publication, and have given 7 invited seminars on this combustion research at universities and industry.

List of Publications and Presentations (9/30/97 - 5/30/98) on

"Development of a Novel Radiatively/Conductively Stabilized Burner for Significant Reduction of NO_x Emissions and for Advancing the Modeling and Understanding of Pulverized Coal Combustion and Emissions" (DOE Grant No. DE-FG22-97PC97273)

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Publications

N. Lior, C. Kim and N. Arai, "Simple approximations for the spectral radiative properties of pulverized coals in combustors", Proc. 35th National Heat Transfer Symposium of Japan, May 27-29, 1998, Nagoya, Japan (accepted, also for presentation).

C. Kim and N. Lior, "A numerical analysis of NO_x formation and control in radiatively/conductively-stabilized pulverized coal combustors", the J. of Chem. Engng. (accepted)

Invited seminar presentations by the PI-s

University of Arizona;
Åbo Akademi University, Finland;
Luleå University of Technology, Sweden
MEFOS (Foundation for Metallurgical Research), Sweden
University of Lund, Sweden
Chalmers University of Technology, Sweden
Nagoya University, Japan.